§1. Further Development of Neutral Beam Injection Power in the 11th Campaign

Takeiri, Y., Kaneko, O., Oka, Y., Tsumori, K., Osakabe, M., Ikeda, K., Nagaoka, K., Asano, E., Kondo, T., Sato, M., Shibuya, M., Komada, S.

The LHD is equipped with four neutral beam injectors (NBIs). Three of them (BL1, BL2 and BL3) are negative-ion-based NBIs with high-energy tangential injection at 180keV, and the other (BL4) is a positive-ion-based NBI with low-energy perpendicular injection at 40keV.

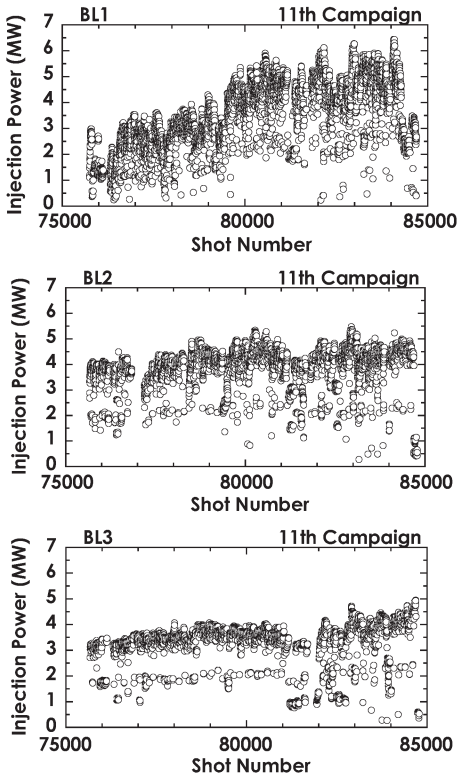

Fig. 1. Histories of the injection power for the individual injectors of BL1, BL2, and BL3.

Each negative-NBI is designed for 180keV-5MW injection, and the achieved injection power until FY2006 (10th campaign) was 13.8MW in total. Figure 1 shows the injection histories for BL1, BL2, and BL3 in the 11th campaign. In BL2, the accelerator of the negative ion source was modified, so that the secondary electrons generated inside the extraction grid (EG) aperture would not be accelerated downstream. As a result, the heat load of the grounded grid (GG) was reduced, and the voltage holding ability was improved during the beam acceleration. The injection power of BL2 was increased, and achieved to 5.5MW at maximum with an energy of 186keV, which exceeds the designed values.

BL1 has already achieved 190keV-6MW injection in the 10th campaign using negative ion sources with slotted GG. In the 11th campaign, since the calorimeter was deformed due to an excess heat load, the conditioning of high-power beam was restricted. As a result, the injection was unstable at high power. Even in this condition, however, higher-power injection of above 6MW was occasionally achieved.

In BL3, due to deterioration of the voltage holding at the extraction gap, the beam energy was not raised and, consequently, the injection power was less than 4MW until SN=82000 when the problem was solved. After that, the injection power was increased to 175keV-4.9MW.

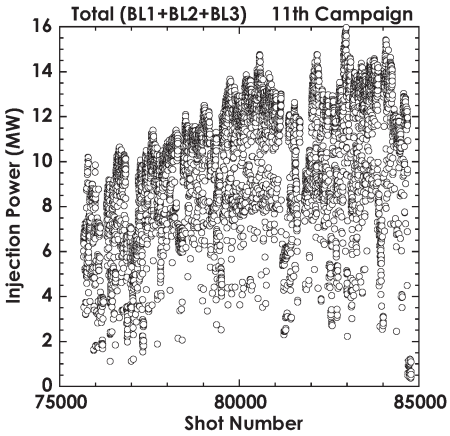

Fig. 2. History of the total injection power in the 11th campaign.

Figure 2 shows the injection history of the total injection power with three negative-NBIs. The maximum power is recorded at 16MW, which exceeds the target value of 15MW. However, the injection duration is shorter than 1.5sec, and, thus, extension of the high-power injection duration is required

The positive-NBI of BL4 started its operation in 2005, and the designed values of 40keV-6MW have already been achieved although the injection duration is limited below 1sec to avoid an excess heat load on the residual beamdump due to the unexpected beam focusing. In the 11th campaign, by shortening the injection duration further, the injection power is increased to 8MW at the injection duration of 0.3sec, as shown in Fig. 3.

The total injection power of 22MW at maximum including the negative- and positive-NBIs was available to the LHD experiments in the 11th campaign. This high power plasma heating provided a wide variety of the experimental conditions and contributed to the improvement of the LHD plasma performance.

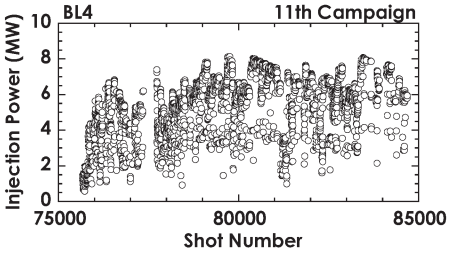

Fig. 3. History of the injection power of BL4 in the 11th campaign.